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STUDY OF THE ECONOMIC IMPACT OF SULFUR REGULATIONS PROMULGATED BY THE U.S. ENVIRONMENTAL PROTECTION AGENCY FOR OHIO ON AUGUST 27, 1976

STUDY DOCUMENT NUMBER 10. COAL PRICES USED IN STUDY OF ECONOMIC IMPACTS OF SULFUR OXIDE REGULATIONS IN OHIO

ENERGY AND ENVIRONMENTAL ANALYSIS, INCORPORATED,
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16. ABSTRACT

This report is the tenth volume in support of the Inflation Impact Statement for sulfur dioxide regulations prepared by the U.S. Environmental Protection Agency, to correct deficiencies in the Ohio State Implementation Plan. The Technical Support Document, Volumes I and II may be obtained through the National Technical Information Service - EPA 905/2-76-002, PB-257 694 and PB-257 695.

This document presents as input data estimates of delivered coal prices to Ohio by sulfur content, especially the estimated price premium for low sulfur over high sulfur coal. Described are recent coal price trends in terms of appropriateness for the regulatory compliance by Ohio coal users.

PRICES SUBJECT TO CHANGE

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Coal Prices Used In Study of Economic Impacts of Sulfur Oxide Regulations in Ohio

Part of a Study of the Economic Impact of Sulfur Regulations Promulgated by the U.S. Environmental Protection Agency for Ohio on August 27, 1976

Prepared for:

Office of Planning and Evaluation
Office of Air Quality Planning and Standards
United States Environmental Protection Agency

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September 11, 1976

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SECTION I

PURPOSE

The analysis of the impact of the SO_2 regulations prepared by the Environmental Protection Agency for Ohio required as inputs estimates of delivered coal prices to Ohio by sulfur content, especially the estimated price premium (i.e., differential) for low-sulfur over high-sulfur coal. These prices were used in the study for the utility and industrial sector cost analyses. The prices used had to be appropriate for the time period and circumstances of the timing of compliance by Ohio coal users.

Coal prices are dependent on the FOB mine price of coal, processing costs (for coal cleaning) if any, and transportation costs to the user. FOB mine prices, which are the least certain component of these costs, depend on production costs of coal of various sulfur contents and on market conditions. This paper describes recent coal price trends, the methods used for developing price estimates, and presents the prices developed as inputs to the other elements of the Ohio study. Because of the many uncertainties surrounding future coal prices, several alternative estimates were developed, including continuation of current trends, and prices reflecting alternative assumptions about the stringency and compliance timetable of sulfur emission regulations in the nation.

The relationship of this background document to other study documents is described in Appendix A.

SECTION II

BACKGROUND AND ISSUES

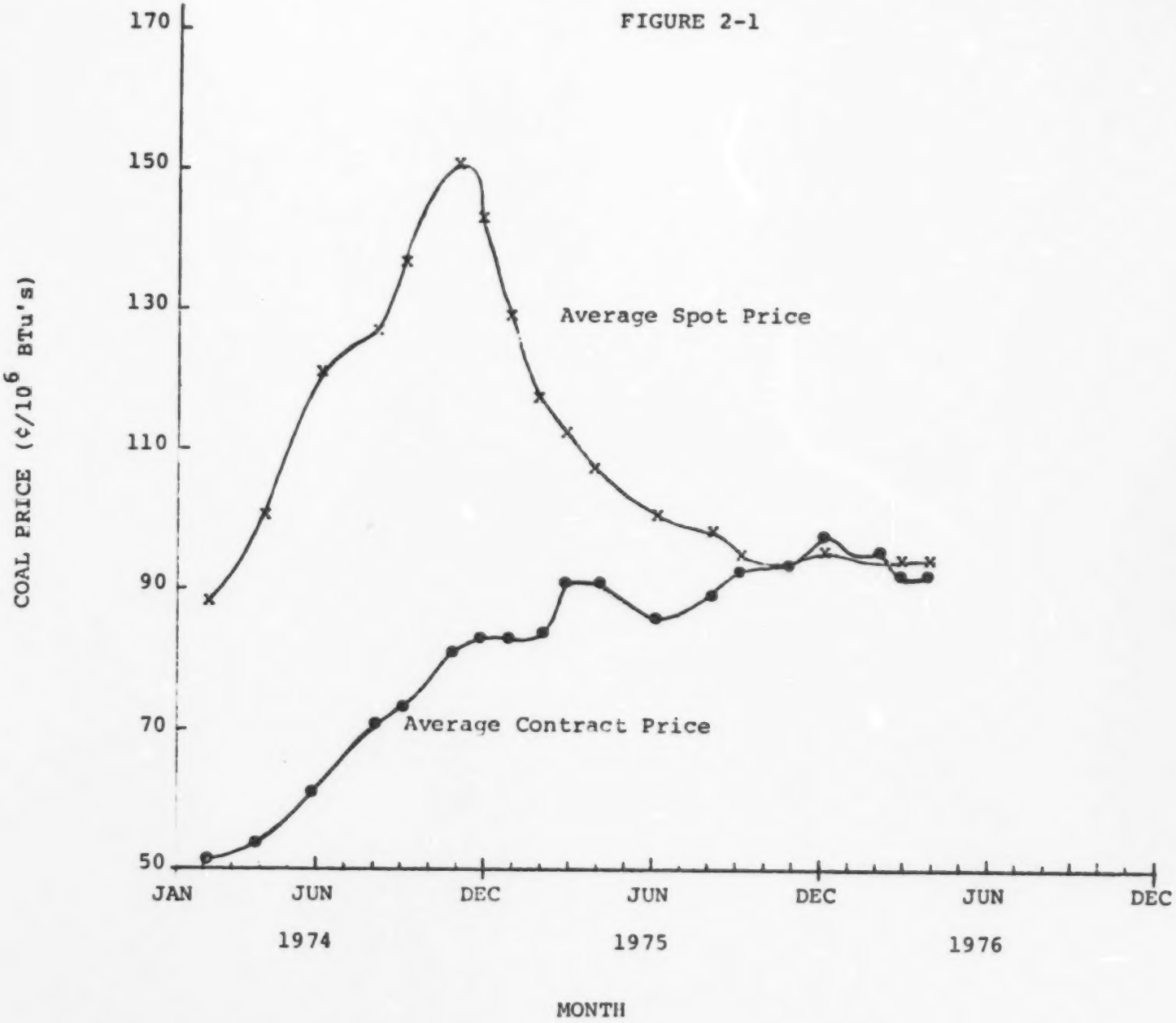
A. Current Coal Prices

Ohio coal consumers now receive coal shipments of Ohio, Pennsylvania, West Virginia, Kentucky and Western coal origins. These shipments are transported by rail, water and truck and have delivered costs ranging between $.50 and $1.50 per million Btu. Some of this coal is received on a spot purchase basis and some of it on long-term contracts dating back many years. Contract terms and the variation in quality, sulfur content, Btu content, transportation costs and other factors determine where, within this wide range, each consumer's purchases fall. Data about the source and prices of coal purchases is fairly scanty. Census data on prices paid by industrial consumers are updated only every few years. Federal Power Commission Form 423 data reports only delivered prices to utilities. The Federal Power Commission price data does not include the dates at which contracts were signed. Consequently, the delivered prices are averages reflecting price implications of agreements reached many years ago, as well as new contract terms.

Coal prices have also been changing very rapidly over the last two years. While they peaked more than a year ago at prices approaching $2 per million Btu, spot coal prices have dropped steadily since then. But since they are still at levels two to three times what they were only four years ago, there is still great uncertainty regarding the future level and direction of movement of coal prices. Figure 2-1 shows the recent trend of spot and contract prices of coal used in Ohio utilities. Current coal prices may not, however, serve as an appropriate indicator of the costs that utilities and industrial consumers of coal can expect to pay when they have to comply with the

COAL DELIVERIES IN OHIO

FIGURE 2-1



SOURCE: FPC News

sulfur dioxide regulations by December 31, 1979.

Future coal prices will be affected by basic supply and demand factors as well as short term circumstances, such as weather conditions. This study focuses on likely trends in the price premium for low sulfur coal. If that premium is low or negligible then low sulfur coal would be used to comply with emission regulations instead of more expensive control equipment. The economic impact of stringent sulfur regulations in Ohio thus depends critically on whether the low sulfur coal premium is $.10 or $.80 per million BTU.

The price premium for low sulfur coal to Ohio consumers will be determined by factors affecting the national coal market, since Ohio users must compete with other states which are also trying to solve pollution problems and satisfy energy demands. The critical determinants of the price premium for low sulfur coal include:

- the national growth in coal demand
- the share of coal demand which is required by regulations to be of low sulfur content
- the cost of alternative means of sulfur removal such as flue gas desulfurization devices
- the pace of development of low sulfur coal reserves

B. Coal Demand

In the next four to five years, critical factors affecting the national demand for coal include:

- growth of electricity demand
- resumption of industrial growth and fuel mix choices for new plants
- natural gas availability and pricing policy
- utility financial problems delaying installation of new capacity
- use of FEA authorities to convert existing utility and industrial plants to coal and to order new units to burn coal

TABLE II-I

Utility Compliance with Sulfur Regulation[1/]
(1974 Coal Quality)

Region	Coal Use (million tons)	In Compliance (%)
Midwest	149	24
Southeast	108	49
Northeast	67	65
Other	50	57
Nation	374[2/]	43

1/ Adapted from Coal and the Clean Air Act prepared by EEA for National Science Foundation Contract #NSF-C981 1975.

2/ Based on FPC Form 423 data for calendar year 1974, sample included 97% of total utility coal reported to FPC.

TABLE II-2

COMPLIANCE SINCE 1969 IN COAL BURNING PLANTS [1/]

Region	Percent of Total Demand	Percent of Coal Out of Compliance 1969	1974	% Improvement (Deterioration) in #$SO_2/10^6$ BTU
Midwest	40%	85	87	9%
Southeast	30%	56	68	(9%)
Northeast	20%	78	39	8%
West	10%	59	54	27%
NATIONAL	100%	73	70	7%

[1/] EEA Coal and the Clean Air Act op cit

A key factor in terms of the price premium for low sulfur coal is the likely shift in demand toward lower sulfur coal as a consequence of sulfur emission regulations. Substantial shifts toward lower sulfur coal have not yet occurred. Although the state regulations designed to achieve the ambient air quality standards for sulfur dioxide were adopted in 1972, major coal users are still out of compliance with the regulations. Table II-1 shows the percentage of utility coal energy out of compliance in 1974. As Table II-2 illustrates, there is little evidence to date that utilities have tried to purchase more low sulfur coal. This status report indicates that compliance problems are especially severe in the midwestern states such as Ohio. Complete compliance with sulfur regulations is likely to result in a radical shift in demands by sulfur content which would be met by appropriate quality or higher sulfur coal plus flue gas desulfurization equipment. Thus, the price premium for low sulfur coal hinges on how regulations affect the quality of coal demand in the 1976-80 period when many states are attempting to realize aiq quality goals. Table II-3 compares the current mix of steam coal demand by sulfur content with current regulatory requirements. This comparison shows the massive shifts in demand for low sulfur coal or sulfur removal equipment that would accompany compliance with these regulations. However, regulations continue to be in a state of flux in Illinois, Indiana, and West Virginia - all major coal using states. Since litigation over regulations is expected to continue, there is great uncertainty over the structure of regulations and the pace of compliance. Any analysis of coal prices must be based on explicit assumptions regarding the regulatory scenario.

C. Uncertainties Affecting the Future Supply of Coal

A major uncertainty affecting all coal consumers is the rate at which coal prices may increase due to increases in production costs. Over the last year coal prices on the average have increased

TABLE II-3

SULFUR CONTENT OF STEAM COAL DEMAND 1980
% OF TOTAL STEAM COAL DEMAND[1/]

	Sulfur Content (lbs of SO_2/MMBTU)		
	≤ 1.2	1.2-3.3	>3.3
Under Sulfur Regulations[2/]	49.0	37.0	14.0
Existing Coal Consumption[3/]	15.0	27.0	55.0

1/ Includes utility and industrial steam coal uses.

2/ Includes SIPs now being challenged or revised. Includes new plants (under New Source Performance Standards 1.2 lbs SO_2/MMBTU. See Coal and the Clean Air Act EEA.

3/ Utility coal consumption by sulfur content from FPC Form 423 data for July '74-June '75 cited in Effect of Air Quality Requirements on Coal Supply USBM 1976. Other uses sulfur content distribution from USBM Minerals Yearbook 1973; Coal-Bituminous and Lignite, Table 44.

very slightly and spot coal prices have dropped substantially. Some people argued that coal prices would rise very quickly to a $/Btu equivalence with oil prices, about $2/MMBtu. This is plainly not happening. Nonetheless, coal prices are likely to rise. What are the factors that are driving them up? Inflation is certainly one. Decreases in productivity which have occurred each year since 1968 are another, as well as additional reclamation requirements for surface mines and safety requirements for underground mines. On the other hand, many coal producers hope that the decline in productivity can be reversed fairly quickly and that this side of the equation, production costs, will stabilize.

Production costs for eastern low sulfur coal, particularly if large increases in output are sought, are another question. Relatively little steam coal of the sulfur content required to meet the Federal New Source Performance Standard for SO_2 (i.e., 1.2 lbs. SO_2 per million Btu heat input to boilers) is now produced in the eastern United States, somewhat less than 30 million tons out of 500 million tons total eastern production. It is argued that this coal is more expensive to produce, since it is in thinner seams and small tracts. However, because there was no special reason to seek out low sulfur coal before the advent of Clean Air Act regulations, no one is very sure how much more it will cost to mine.

Production costs for western low sulfur coal are also somewhat uncertain, partly due to the possibility of continued constraints on expansion due to Federal leasing policies, or the effect of measures such as Montana's recent enactment of a 30 percent ad valorum severance tax on coal.

If shifts in demand toward lower sulfur coal do occur, then the pace of development of low sulfur coal supplies will be a critical determinant of the price premium for low sulfur coal. If supplies are highly inelastic, low sulfur coal

coal. If supplies are highly inelastic, low sulfur coal prices will tend to be determined by the costs of high sulfur coal plus washing or flue gas desulfurization devices. If the supply response is great enough, then low sulfur coal would capture a greater share of the market generated by stringent regulations, driving down the price premium as a consequence of competition among suppliers of low sulfur coal.

SECTION III

FOB MINE PRICES

A. Alternatives Considered

Considering these many uncertainties, EEA determined to try two alternative approaches to the problem of estimating coal prices and the sulfur premium (i.e., price differential between high and low sulfur coal).

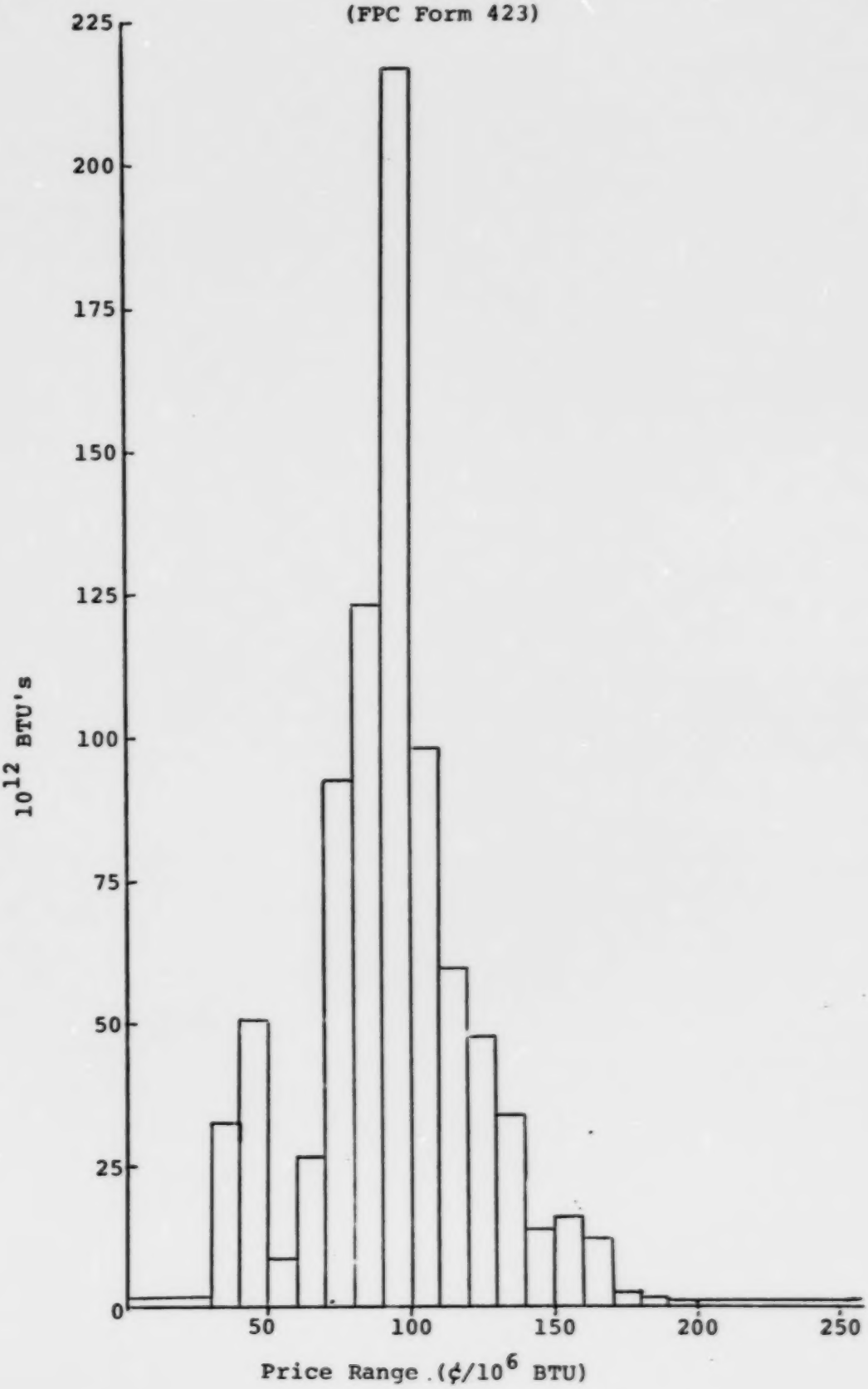
One approach was to derive the FOB mine prices implied by the current prices of coal delivered to Ohio. This set of FOB mine prices would serve as a reference case. The second approach was to estimate prices in 1980 to 1982 based on a model which incorporates explicit assumptions regarding overall coal demand, transportation costs, production costs, a regulatory scenario determining the demand mix by sulfur content and the likely maximum availability of low sulfur coal by 1980. The methodologies used for both sets of FOB mine prices and for estimating transportation costs are described below.

B. FOB Mine Prices - Current Prices

1. Variability of Prices

Coal prices have fluctuated rather widely during the last three years (especially since early 1973), as Figure 2-1 above showed. A more detailed examination reveals that the results of these changes is that prices of coal delivered to Ohio utilities vary by a factor of three. Figure 3-1 below gives a distribution of Ohio utility coal purchases by price. This figure shows a tremendous spread. This is at least partly due to coal sold on long-term sales contracts which includes prices set long before the rapid escalation of prices in 1973-74, prices set at the peak of the pre-strike coal boom of July through

FIGURE 3-1
DELIVERED COAL PRICES - OHIO UTILITIES
JAN. - NOV. 1975
(FPC Form 423)



November 1974, and the prices set during the last year or so. It is difficult to discern a 'price' among all these, or to imagine that this situation reflects a long run equilibrium.

With these caveats in mind, EEA derived estimated FOB mine prices for coal, by sulfur content and producing region. The methodology is summarized below.

2. Estimating Method

Coal prices were estimated as follows:

1) January-October 1975 FPC Form 423 reports were selected as the sample period, because 1974 data reflects the disruptive effects of the UMW strike and October was the latest month available at the time of the analysis.

2) The average price of coal delivered to each plant by producing region (Bureau of Mines district, which is recorded on Form 423) and sulfur content was computed, by computer processing of a tape of the FPC data.

3) The estimated transportation cost (see below) was subtracted from this price to yield an estimated FOB mine price by producing region and sulfur content.

4) Prices of coal delivered to all for each sulfur content category were averaged to derive an average price by sulfur content by producing region.

This results in a matrix of FOB mine prices by origin and sulfur content. The matrix is reproduced in Table III-1.

TABLE III-1

FOB MINE COSTS AND VOLUME CONSUMED[1/]

(Current Prices)

Region	Sulfur Content (% by weight) .6-.8	.8-1	1-2	2-3	3
Pennsylvania					
Price			84.0	85.6	96.3
Volume			5.088	30.057	18.782
Ohio					
Price			78.75	74.4	81.1
Volume			5.116	91.29	409.82
Northern West Virginia					
Price				96.4	55.4
Volume				30.924	56.916
Southern West Virginia					
Eastern Kentucky					
Price	87.3	93.4	96.7	104.5	96.6
Volume	8.106	47.708	65.366	11.514	7.14
Western Kentucky					
Indiana					
Price				31.5	31.5
Volume				13.896	23.273
Colorado, Utah					
Price	110.8	116.4			
Volume	2.973	2.270			
Montana, Wyoming					
Price	12.0	14.8			
Volume	6.408	4.648			

1/ Cost in ¢/10^6 Btu - Volume in 10^{12} Btu

with the sulfur regulations in each state, this would be evidence that there is not additional cost for Ohio coal burners to comply. However, as was discussed earlier, no large shift to low sulfur coal has as yet occurred. These prices thus to not adequately reflect the demand situation which will prevail when Ohio coal users are required to comply in 1980. As a result, they were judged to be an inappropriate basis for determining low sulfur coal premiums.

C. Hypothetical or Projected Prices - FOB Mine

1. Purpose

In order to provide a more realistic estimate of the price premium for low sulfur coal, EEA used a method of estimating future prices which takes into account the production costs of high and low sulfur coal and 1980 coal demand by sulfur content. The underlying logic is that at some time in the future, coal producers and consumers will have had an opportunity to adjust to the effect of the sulfur emission regulations and the coal market might settle into a new quilibrium. The time required depends on the construction and development time for new mines, construction of scrubbers, termination of old sales contracts. for non-complying coal, and other measures necessary to come into compliance. EEA's analysis assumes that in 1980 to 1982 all consumers will comply. The prices that the market would determine under these circumstances are the result of a complex set of factors involving consumers in dozens of states and coal producers across the country. In order to simulate this market situation, EEA used its coal supply-demand model.

2. Structure of the Model

The EEA coal supply-demand model, developed to analyze the effects on coal of the Clean Air Act in a national context, is a large linear programming model.[1/] Models of this type contain a number of elements which are combined to approximate a market solution. In this case, the elements consist of coal supplies and coal demands, and optimality is defined as the least cost combination of coal, with or without scrubbers, which will satisfy a set of sulfur regulations. The basic elements of the model are coal production costs by region and sulfur content, coal transportation costs (between all producing and consuming regions), demands for coal by sulfur content in each demand region and costs for FGD as a function of plant characteristics. The relationship of these elements is portrayed in Figure 3-2.

One of the distinguishing characteristics of the model is the level of detail of the model data base. The basis for costs in each sector is briefly described in Figure 3-3 below.

The model operates by considering various possible combinations of coal supplies, consumers, FGD, and chooses a solution which minimizes the total cost of coal, transportation and pollution control equipment. For a more complete description of the model logic, see Appendix B. The solution reached simulates what would happen in a perfectly competitive market at equilibrium. The supply side (coal supply curves) of the model was developed by an engineering cost approach to the costs of underground and strip mines. For example, the cost of surface mined coal is

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1/ EEA, Environmental Standards and Coal prepared for Office of Coal, FEA contract #50268, Feb. 1976.

FIGURE 3-2

COAL SUPPLY/DEMAND MODEL

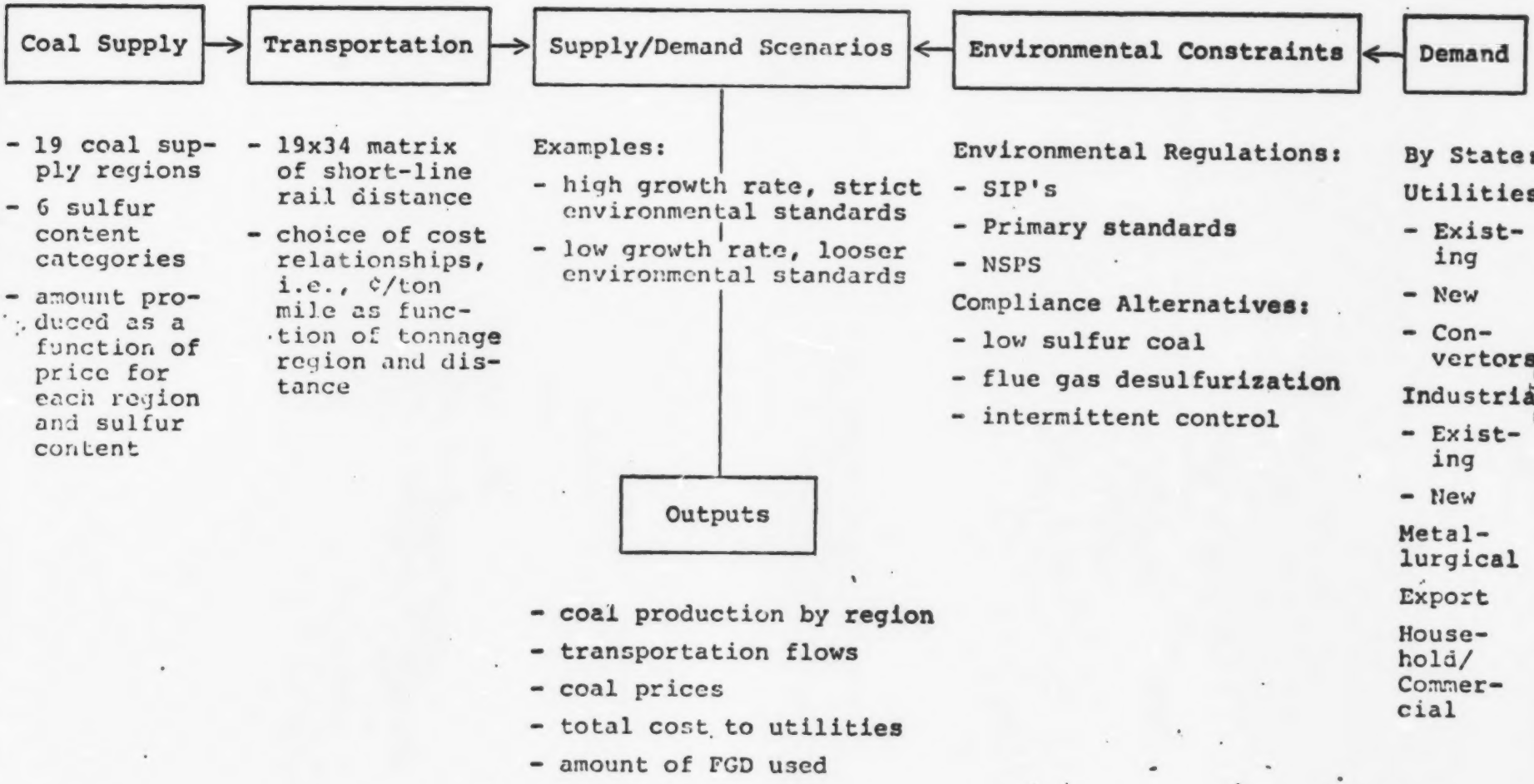

Figure 3-3

Detail Structure of
Principal Model Elements

Control Options	Parameters	Empirical Application
Coal - Strip Mine	- Cost by stripping ratio - Cost by location of mine - Reserves by sulfur content classified	- 5 cost elements - Reserves classified by cost element, sulfur content - 19 coal supply regions
Coal - Underground Mine	- Cost by seam thickness, mine size - Cost by location of mine - Reserves classified by sulfur content	- 15 cost elements - Reserves classified by cost element, sulfur content - 19 coal supply regions
Flue Gas Desulfurization	- Cost of new versus retrofit - Cost by boiler size - Adjusted for coal to be cleaned - Least cost choice of boilers to apply FGD	- 4 boiler capital cost classes - 6 FGD cost classes per region (¢ MMBTU) - 34 demand regions - cost/MW determined at plant level

largely a function of the stripping ratio (overburden to coal ratio). As more overburden is moved per ton of coal, costs increase. As higher stripping ratios are achieved, more (deeper) coal is recoverable and production can increase. Thus a supply curve is constructed.

Demand for coal is built up from plant-by-plant or AQCR specific regulations for coal-fired plants across the country. New plants are projected to meet an assumed demand of 605 million tons of coal used by utilities and 103 million tons used by industrial consumers in 1980.[1/] These projections reflect an optimistic view of coal expansion as shown by a comparison with recent FEA forecasts as shown in Table III-2.

Coal demand is further broken down according to the cost of installing FGD at each plant. New plants have the lowest costs since they allow longer amortization periods for capital investment and the highest capacity utilization rates to spread the costs. Conversely, costs for old plants with short remaining lives would be increased more by installation of a scrubber.[2/]

Because several alternative regulations and regulatory strategies for implementing the Clean Air Act have been debated, the demand sector of the model was prepared to include alternative sets of regulations. Without going into detail on the differ-

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1/ Environmental Standards and Coal, Final Report, EEA Inc. prepared for Federal Energy Administration, Contract #50260, Feb. 1976.

2/ The Ohio analysis (discussed in document #6) included the effects of electrostatic precipitator upgrading (where low sulfur coal is used) and the derating of boilers using low-Btu western coal. These considerations were not included in the coal supply-demand model in the version used to develop price inputs to the Ohio analysis.

Table III-2
COMPARISON OF EEA[1/] AND FEA[2/]
COAL DEMAND FORECASTS
1980
(millions of tons)

Sector	EEA	FEA
Coke	100	95
Industrial Steam	103	89
Commercial and Household	12	6
Metallurgical Exports	58	80
Steam Coal Exports	25	
Electric Utilities	605	528
Total Demand	903	798

1/ EEA, Coal and the Clean Air Act, prepared for NSF Contract # NSF-C981, June 1975.

2/ FEA, National Energy Outlook, p. 180 (reference scenario, 1980).

ences,[1/] it is important to point out that the regulations-set used to develop coal price outputs for use in this study should be considered fairly stringent. It assumes some relaxation of current state regulations as recommended by the USEPA and that a relatively few isolated rural plants would still be allowed to use intermittent (also called supplementary) control systems or otherwise delay full compliance beyond 1980. Therefore, this set of regulations yields a relatively high estimate of low sulfur coal demand.

3. Coal Availability

Production costs are the determinant of the shape of the coal supply curve for each region and sulfur content. Low sulfur coal may be priced higher than high sulfur coal because it costs more to mine. However, production costs are only one factor which may result in a price premium for low sulfur coal. If too few low sulfur coal mines are opened to meet the 1980 demand because of time delays in construction or shortages of men or equipment, coal users will tend to compete for the available supplies. They can afford to bid up the price of low sulfur coal to the cost of alternative means of compliance such as flue gas desulfurization. For example, suppose high sulfur coal costs $15.00 per ton, and the cost of scrubbers is equivalent to $9.00 per ton (which is approximately the scrubber cost for new plants). Coal consumers would be willing to pay up to $24.00 per ton for low sulfur coal no matter what it costs to produce. The model simulates such comparisons between competing sources of low sulfur coal and FGD to determine market prices.

Since opening new mines can take as long as 3 to 6 years (depending on type, size and location), one possibility is that there will be a shortage of low sulfur coal. While no one knows how much new mining capacity could be completed by then or

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1/ EEA, Environmental Standards and Coal prepared for Office of Coal, FEA Contract #50268, Feb. 1976.

what the bottlenecks would be, there are estimates available of the new mine openings now planned by coal producers. These estimates (one version prepared for the FEA Coal Advisory Committee and another by Coal News) provide a basis for putting limits on the potential production of low-sulfur coal in Appalachia and the west. Table III-3 shows the constrained and unconstrained potential production estimates developed by EEA, as well as FEA Project Independence Blueprint estimates to serve as a reference point. Constrained production means the maximum production possible from existing plus announced new mines. Unconstrained production means the maximum possible production, limited only by reserves (except for the western states where reserves are so large that the "unconstrained" production is merely a more optimistic forecast of mine openings). Because the Ohio analysis focuses on 1980, it was felt that the constrained production estimates provided a more appropriate basis for estimating prices. When the coal supply-demand model is run with these limits placed on coal production. The low sulfur coal premium will tend to be higher than if compliance were stretched out over a longer interval.

4. Results and Caveats

As Table III-4 shows, low sulfur coal prices under these assumptions of constrained supply and relatively stringent regulations are considerably higher than the prices for high sulfur coal. The price premium amounts to about $.47/MMBtu or about $11.00 per ton in West Virginia. These coal prices formed a basic input to the Ohio analysis. The price estimates are an attempt to reflect the supply-demand situation which is likely to prevail when the Ohio coal users must comply with sulfur emission regulations.

TABLE III-3

CONSTRAINED VS. UNCONSTRAINED PRODUCTION POTENTIAL FOR KEY STATES[1/]

Producing States	1973 Production	1980 EEA Uncon	1980 EEA Con	1980 PIB Accel Devel	1980 PIB BAU
Northern Appalachia					
Pennsylvania, Maryland	78	417	115	146	98
Central Appalachia					
Virginia	34	80	43	---	---
W. Virginia	115	706	168	---	---
E. Kentucky	74	193	97	---	---
Subtotal	223	979	308	491	327
Northern Great Plains					
Wyoming	15	180	119	---	---
Montana, N.Dakota, S.Dakota	18	70	72	---	---
Subtotal	33	250	191	187	102
Southwest					
Kans, Texas, Oklahoma, Missouri New Mexico, Arizona, Utah, Colorado	33	244	161	123	70
TOTAL	367	1890	775	947	597

[1/] States not listed were left unconstrained in both scenarios.

TABLE III-4

FOB Mine Prices - Estimated by Supply/Demand Model [a/] [b/]
(with cleaning costs)

Supply Region	Sulfur Content Category 01 (.6-.8%)	02 (.8-1.2%)	03 (1.3-1.7%)	04 (1.8-3.3%)	05 (3.4-5.0%)	06 (5.0%)
Pennsylvania			96.2	77.3	61.2	55.9
Ohio					59.1	49.5
Northern West Virginia					65.9	65.9
Central Appalachia	113.0	89.5	88.7	75.7	65.9	65.9
Midwest (Indiana, West Kentucky)						49.5
Utah-Colorado		58.0	58.0			
Northern Great Plains		34.5	24.0			

[a/] Cost in ¢/10^6Btu

[b/] These prices are from the Model Run called "ICS 90 1980 Constrained Perfect Market Price"

It should be noted that these price premiums were generated using the old state regulations for Ohio. Logically, the results in Ohio of this analysis based on these price premiums should have been reinserted into the model to determine whether the change in regulations in Ohio significantly affected the price premium for low sulfur coal. Time constraints did not permit such an iterative process. Since the old regulations in Ohio were far more stringent than those promulgated on August 27, 1976 by the USEPA, this omission tends to overstate the price premiums for low sulfur coal used in this study.

SECTION IV

COAL CLEANING

A. Purpose

One modification was made in the coal price matrix produced by the coal supply-demand model to take account of the possibility of coal cleaning. The model does not provide for coal cleaning. All coal is assumed to be shipped raw (i.e., run of mine). But in some cases, high or medium sulfur coal might be cleaned (i.e., mechanically washed) to reduce the sulfur content significantly. Two degrees of cleaning were considered. A 'moderate' level of cleaning which would reduce coal sulfur from 3.5-5 lbs/MMBtu to 1.8-3.3 lbs. or 1.8-3.3 to 1.3-1.7 lbs. and a 'deep' level of cleaning to reduce sulfur greater than 5 lbs. SO_2/MMBtu to 1.8-3.3 lbs. SO_2/MMBtu. Costs for the two levels of cleaning were calculated and where the cleaned coal was cheaper than uncleaned coal of the same sulfur content, or where no coal of that sulfur content was available before, the cleaned coal supply and price was inserted. This is illustrated in Table III-4A; the cleaned coal elements are circled. For those cases, coal washing appeared to be an economical alternative.

B. Cleaning Cost Methodology

1. Technology

Two technologies were evaluated. The first is a shallow cleaning process corresponding to cleaning at 1.6 specific gravity separation in cyclones, which separates heavier ash and sulfur bearing material from the coal. The other is a deeper coal cleaning using one stage of conventional cleaning at 1.6 gravity separation and a second stage of a more speculative technology, namely flotation of pyrite from the coal particles. This process can remove as much as 90 percent of the pyrite content of the coal feed. It is approaching the commercial stage under development by the Bureau

TABLE IV-A

FOB Mine Prices - Estimated by Supply/Demand Model [a/] [b/]
(with cleaning costs)

Supply Region	Sulfur Content Category 01 (.6-.8%)	02 (.8-1.2%)	03 (1.3-1.7%)	04 (1.8-3.3%)	05 (3.4-5.0%)	06 (5.0%)
Pennsylvania			96.2	77.3	61.2	55.9
Ohio				75.0	59.1	49.5
Northern West Virginia				82.4	65.9	65.9
Central Appalachia	113.0	89.5	88.7	75.7	65.9	65.9
Midwest (Indiana, West Kentucky)				76.2		49.5
Utah-Colorado		58.0	58.0			
Northern Great Plains		34.5	24.0			

[a/] Cost in ¢/10^6Btu

[b/] These prices are from the Model Run called "ICS 90 1980 Constrained Perfect Market Price"

of Mines. Contact with a BOM researcher[1/] indicated that it was likely that this technology would be available by 1980. It permits a much greater reduction in pyrite content without the high losses of Btu content associated with deep cleaning of high sulfur coal in conventional cleaning plants. The sulfur removal efficiencies are based on average data for coals produced in these regions from the U.S. Bureau of Mines.[2/]

2. Cost Factors

Cost factors were calculated on capital and operating costs for each type of plant based on cleaning plant costs developed by PEDCO (see Document #8) which included capital costs ($/ton/hour), raw material, utility, labor, maintenance and supply costs. These were all converted to costs per ton or annual ton based on the PEDCO figure of 6000 hours of operation/year. The capital costs were then annualized, using an algorithm which allowed a specified rate of return, and the cost converted to a cents per million Btu increment to the raw coal cost.

Only two significant cases of coal cleaning resulted. Ohio and Pennsylvania coals of 2-3 percent sulfur were cleaned to the 1-2 percent range by single stage cleaning at 1.6 specific gravity. The total cost of cleaning for these coals was $.152/MMBtu. In most other cases, run-of-mine coal of acceptable sulfur content was cheaper than higher sulfur coal plus washing costs.

1/ Personal communication with Mr. Ken Miller, U.S. Bureau of Mines Pittsburgh. See also U.S. Bureau of Mines Report of Investigation Number 7822; also Transactions ASME, Vol. 258, March 1975.

2/ Bureau of Mines, Report of Investigation Number 8118: Sulfur Reduction Potential of the Coals of the U.S. Department of Interior, 1976.

SECTION V

TRANSPORTATION COSTS AND ORIGIN-DESTINATION PATTERNS

A. Purpose

The cost of coal transportation can be a significant portion of the total delivered cost to the consumer. This cost can vary from negligible amounts for a mine mouth plant to an average of 25 to 30 percent of the delivered cost for eastern coal and much more for western coal. Therefore, it was important to be able to estimate accurately the transportation costs of coal from any origin to coal consumers in Ohio.

B. General Approach

The steps involved in a study of transportation costs are as follows. First, the supply and demand areas must be identified and grouped together insofar as accuracy permits. Next, for each origin-destination pair, all conceivable modes of transportation must be identified and the cost estimated. This includes truck, rail, river barge or lake collier. The final step is to select the lowest cost mode of transportation. In this fashion, a matrix of transportation costs has been developed which shows the lowest cost method of transportation for each origin-destination pair.

In order to minimize the level of detail required (i.e., the number of origin-destination combinations), geographic aggregates of supply sources and consumer locations were developed.

For reasons discussed below, supply areas were aggregated into seven regions: Ohio, Pennsylvania, Northern West Virginia, Southern West Virginia-Eastern Kentucky, Western Kentucky-Indiana,

Colorado-Utah, and Montana-Wyoming. Industrial demand was aggregated into eleven regions, depicted in Figure 5-1. Utility consumers were treated individually and transport costs to each specific plant were estimated.

C. Supply Regions

The coal supply-demand model used to estimate future FOB mine prices provides supply information at a state level (or for a large portion of a state).

FPC data for powerplants state the Bureau of Mines supply district for coal shipments. However, state or Bureau of Mines supply regions (given in FPC data) are relatively large areas, and the distance and cost of transportation from origins within a supply region to a destination will vary somewhat.[1/] This variation generally is not large, except where the origin is very near the destination, and the error introduced by treating a Bureau of Mines supply region as an origin is not of major consequence.

D. Utility Demand 'Regions'

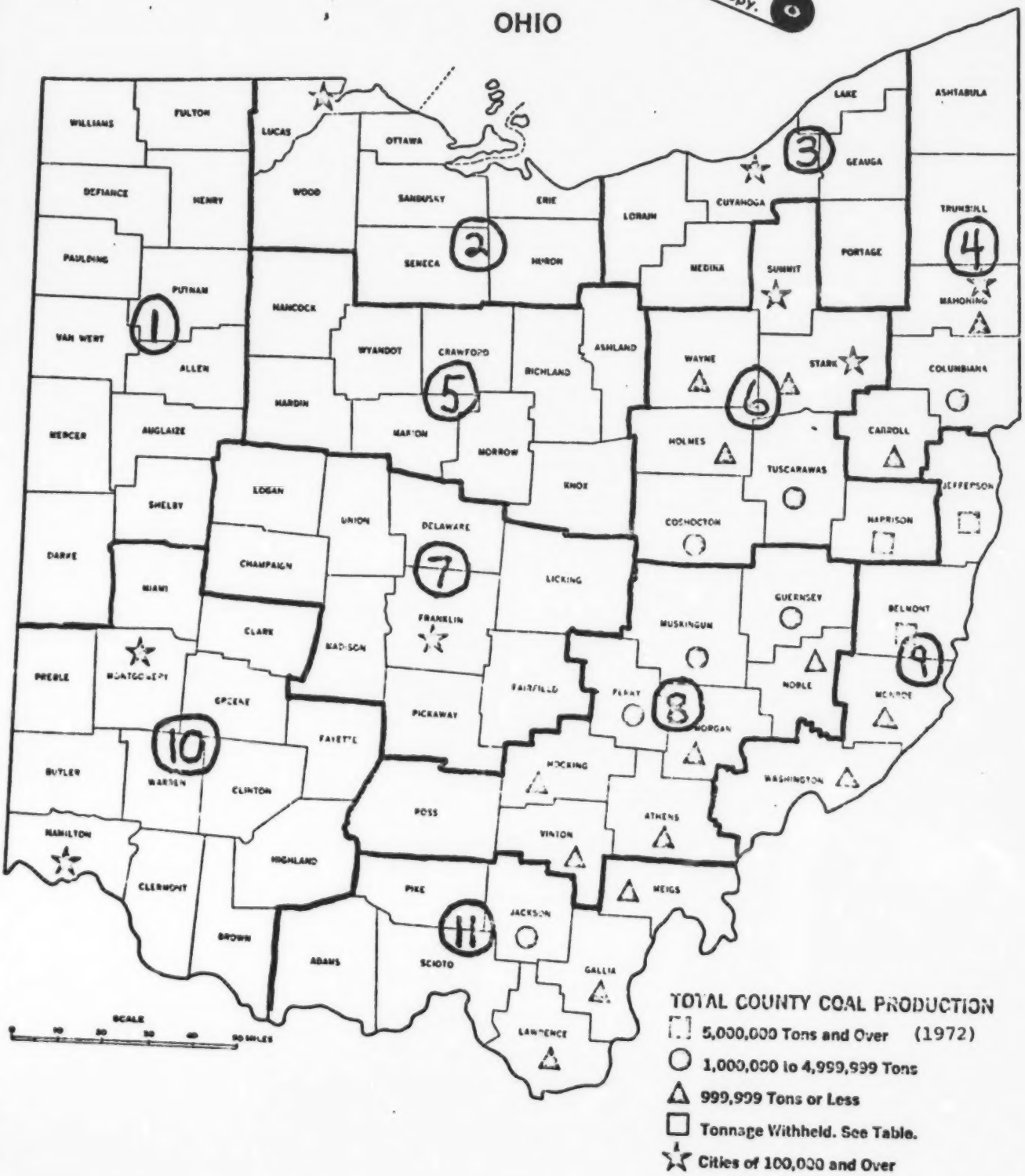
The origin-destination pairs for utilities are based on the actual location of the utility. This type of detail replicates

---

1/ This variation is a particular problem when considering origin-destination pairs which are extremely close to each other. For example, a powerplant on the Ohio River may be receiving coal from the West Virginia side of the river. This will appear as a movement from origin region 3 to that powerplant, and will receive the appropriate rate. However, the actual transportation cost may be far lower than the generic rate from that region. This sort of occurrance is perhaps the main reason why Northern Appalachia coal demand is reduced from current consumption levels in this analysis. Very simply, the delivered cost may be grossly overstated in such movements for a particular plant as a result of the proximity of the origin to the destination.

Figure 5-1

Reproduced from best available copy.



Ohio Demand Regions

Source: Keystone Coal Index, 1974.

the actual origin-destination pairs which are used in setting transportation rates. Utilities are extremely large consumers, and coal transportation to utilities is sometimes subject to essentially negotiated terms with rail or barge companies. For example, rail rates are established which are applicable only to a single powerplant.

E. Industrial Demand Regions

Industrial origin-destination pairs have been developed using destination regions rather than actual plant locations. This was done because the smaller amount of coal sold to industries does not generally place these destinations in the position of negotiating special rates. In addition, industrial sources are more scattered, although they can be grouped into regions based on location.

Destination regions have been developed according to the following logic. First, the rail tariffs were studied to determine the pattern of rates from given origin regions. Next, the patterns of rail rates from each origin region were plotted on a map of Ohio. Destination regions were then drawn according to commonalities in the pattern of rates from different origin regions. The destination regions which have been developed are shown in figure 5-1. These regions are created to be compatible to county boundaries since plant locations could be identified by county.

TABLE V-1

DISTRIBUTION OF BITUMINOUS COAL AND LIGNITE PRODUCED IN THE UNITED STATES DURING THE FIRST QUARTER OF 1976 1/

(In Thousand Net Tons)

GEOGRAPHIC DIVISION STATE OF DESTINATION METHOD OF MOVEMENT CONSUMER USE	TOTAL
East North Central	
Ohio, total	18,123
All methods of movement:	
Electric utilities	12,652
Coke and gas plants	3,080
Retail dealers	219
All others	2,172
All-rail, total	7,133
Electric utilities	3,899
Coke and gas plants	2,281
Retail dealers	89
All others	864
River and ex-river, total	6,263
Electric utilities	5,235
Coke and gas plants	782
Retail dealers	-
All others	246
Great Lakes, total	19
Electric utilities	-
Coke and gas plants	17
Retail dealers	-
All others	2
Truck, total	3,017
Electric utilities	1,827
Coke and gas plants	-
Retail dealers	130
All others	1,060
Tramway, conveyor, and private railroad, total	1,691
Electric utilities	1,691

1/ U.S. Bureau of Mines, Bituminous Coal and Lignite Distribution, July 8, 1976.

F. Existing Coal Origins

The origin of coal sold to Ohio at present has been studied separately for power plants and industrial consumers. Ample data exists to determine the origin of power plant coal on a regional level in the FPC Form 423 reports. No such similar data exists for industrial consumers. The methodology used to develop the existing coal origin regions is described below.

1. Utilities

In the utility sector, FPC for 423 data from the period of January 1975 thru October 1975 was obtained which lists the shipments to each power plant. This data was tabulated for each power plant, and the coal shipped from each origin was noted. The U.S. Bureau of Mines coal producing regions listed in the FPC data were then aggregated to produce the 7 utility supply regions used in this analysis. Therefore, the existing coal origin destination pattern for utilities is based on the available data on current coal consumption.

2. Industrial

The existing coal supply to industrial consumers is based on the delivered cost of coal and data on the current coal sulfur category consumed. Origin-destination data for industrial coal supply does not exist, so assumptions were made according to the following logic. First, the Battelle data on the sulfur content of existing coal was used to place the existing coal into a sulfur class. Next, the existing coal was allocated to the supply regions according to a mapping of the lowest cost coal within a sulfur category (as determined by EEA model delivered costs) to each demand region. The matrix used to produce this supply region allocation is shown in Table V-2.

An example of the use of this matrix is the case of an industrial consumer located in demand region 6. If the Battelle data indicates that this consumer is presently burning coal at

TABLE V-2

EXISTING INDUSTRIAL COAL SUPPLY MATRIX
(Supply region as determined by location
and present sulfur content of fuel)

Demand Region	Sulfur Content (#/MMBtu)					
	.6-.8	.8-1.2	1.3-1.8	1.9-3.3	3.4-5.0	>5.0
1	4	4	4	4	2	2
2	4	4	4	4	2	2
3	4	4	4	4	2	2
4	4	4	4	1	3	3
5	4	4	4	4	2	2
6	4	4	4	4	2	2
7	4	4	4	4	2	2
8	4	4	4	4	2	2
9	4	4	4	1	2	2
10	4	4	4	4	2	2
11	4	4	4	4	2	2

1.2#/MMBtu, the sulfur content category determines that the lowest cost coal which this consumer can purchase of such a quality is from supply region 4.

G. Possible Modes of Transportation

Four different modes of transportation have been considered. These are: rail, barge, truck, and translake shipment. As Table V-1 shows, coal now moves to Ohio consumers by several modes. Clearly, some of these modes are inappropriate for some plants. For example, barge transportation is only really a feasible mode of transportation for plants located along the Ohio river. Translake shipment only applies to western coal moving to plants located near Lake Erie. Truck and rail links are available for most of the facilities, however, there are some powerplants which are located on the Ohio river and receive coal exclusively by water. The costs for each conceivable mode of transportation for each origin-destination pair have been calculated according to the methodology described below.

H. Rail Transportation

Rail transportation is regulated by the ICC, and consequently, the rates which are charged for any commodity are available by searching through ICC tariff statements. In this respect, the data which is available on rail rates is quite good. Unfortunately, the structure of the rail tariff system is incredibly complicated. Some of these complexities have been described in a recent ICC report on the freight rate structure for coal.

> "...it is a fallacy to assume that the railroads have a single freight rate structure on coal or even a single freight rate structure within regions. The railroad rate structures on a particular commodity consist of numerous schedules of charges for rail transportation services. Although these schedules are frequently constructed in conformity with a particular rate scheme, such as on a tapering mileage basis, in most instances the basis or bases for the rates is obscure and if known, that knowledge is limited to the ratemaking railroad or to the most sophisticated tariff expert.
>
> The rate scheme adopted by the ratemaker, or when ordered by the Commission, may be simple or complex:

simple in the case of a mileage rate scale; complex in the case of group-related rates with origin and destination groups varying widely in size and configuration and comprising single-car rates, multiple-car rates, concentration - point rates, annual volume rates, unit-train rates, local rates, export rates, refund rates, joint water-rail rates, joint rail rates, proportional rates, interstate rates subject to the aggregate-of-intermediate and long-and-short-haul provisions of section 4 of the Interstate Commerce Act, and intrastate rates subject to differing state regulatory standards and laws."[1/]

Because of the way in which rail rates are established, no realistic rates exist for large movements to Ohio of coal from the far West (e.g., Wyoming, Montana, Colorado, Utah). However, it is possible to estimate with reasonable accuracy what typical unit train (large volume, single destination) rates would be. Using known rail distances,[2/] and a rough rate formula developed by EEA,[3/] estimates of costs from the origins were prepared. Otherwise, actual rail rates were determined, as described below.

ICC tariffs were reviewed and utilized as follows:

First, the commodity index is consulted to determine which tariffs apply. Then the appropriate tariffs are selected and the basis number is noted for the origin-destination pair of concern. The tariff modifications are then examined for the most current rate which corresponds to the rate basis number. This rate is the rate which applies to the specified coal moved in shipments consistent with the terms of the tariff.

1/ Investigation of Railroad Freight Rate Structure - Coal, ICC Reports ex parte No. 270 (Sub-No. 4), December 3, 1974.

2/ From McNally and Company Handy Railroad Atlas of the United States, Rand McNally Co., 1973.

3/ EEA, Environmental Standards and Cost, Final Report prepared for Federal Energy Administration Contract # 50268,Feb. 1976.

One aspect of rail rates which had to be reconciled was the different tariffs which apply according to the conditions of the shipment. Different tariffs and rates apply to steam coal and metallurgical coal, and the tariff will differ according to the number of cars in a movement (multiple car or unit train rates) and the volume of coal shipped (annual volume rates). Separate tariffs are issued for coal being shipped to a barge loading facility, and for purposes of allowing rail lines to compete with other forms of transport such as barge, truck or slurry pipeline. In fact, the only completely consistent aspect of rail rates is that one rail company is not allowed to have different rates over the same movement from those of other companies.

Where problems such as those described above were encountered in the utility market, the plant deliveries as reported to the FPC were examined to determine the applicability of each tariff. For example, where a single car tariff and multiple car tariffs exist, the rate which was used is an average rate weighted according to the volume of individual deliveries. For industrial rail rates, the tariff used was always the single car steam coal tariff.

I. Truck Transportation

Due to the proximity of Ohio consumers to coal supplies, shipment by truck is a feasible alternative. Generally, truck haulage of coal is competitive with rail on relatively short hauls, but with increased distance rail transportation is much cheaper.

Truck transport costs are only considered for shipments of Ohio coal. This was done because interstate shipments of coal such as those which may occur between Northern West Virginia or Pennsylvania and Ohio are regulated by ICC, and in all probability are at least as expensive as interstate rail transport. In addition, because truck transportation is only cheaper than rail on relatively short hauls, more distant origins such as Central Appalachia will use rail transportation.

Shipment costs were derived with the help of an official of one of the major producers of coal in Ohio who provided truck coal rates from his company's mines to certain destiations (major cities) in Ohio. The road distance was measured between the origin and destination, and a cost curve was constructed with the two parameters being price and distance. Next, this cost curve was used to determine a truck shipment cost for each Ohio demand region based on mileage between the Ohio coal field and the center of each demand region.

Truck haulage was found to be competitive with rail transportation only in 2 demand regions, regions 8 and 9 for the industrial consumers. Powerplant coal delivery modes are somewhat better documented, and it is possible to determine whether a powerplant receives coal by truck, rail, or barge by consulting the Keystone Coal Handbook. Where Ohio coal is received by truck and rail at a powerplant, the transportation costs of these two modes are averaged.

J. Barge and Translake Transportation

Shipment of coal by water is generally the cheapest method possible. In Ohio many powerplants and major industrial sources[1/] are located either along the Ohio river or on Lake Erie, and those on the Ohio river currently receive significant quantities of coal by barge. Water transportation is not regulated by the ICC, and consequently, rates will vary from company to company.

Barge transportation costs were derived in the following fashion. First, a representative of the Ohio River Company was contacted for an estimate of barge rates from given points of loading to given destinations along the Ohio river. A rough estimate was provided which was stated as probably being within 10 percent of actual rates. Next, the distance from the assumed loading point to the powerplant was measured and the rate was adjusted by interpolation from the rate table provided. Next, the rail tariffs to the barge loading points and the loading fee were added to the basic transportation costs for an estimate of the total barge costs.

A bias has been introduced into the barge costs by the assumption that all coal delivered by barge is loaded from rail facilities. The rail tariff to a barge loading port represents a major part of the total delivery cost. It is known that some of the coal transported by barge is loaded by conveyor directly onto the barge, and consequently, no rail costs are involved. However, the significance of this traffic is unknown. In addition,

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1/ Barge costs for industrial sources are not considered.

barge movements only along the Ohio river have been considered. Coal from Central Appalachia moving down the Kanawha River and coal from Northern Appalachia moving down the Monongahela River are not considered. These factors are considered to overstate the barge transportation costs.

Translake shipment is only a factor for Western coal being shipped to powerplants located on Lake Erie. The costs were developed based on the rail rates from the Northern Great Plains to Duluth-Superior, with the addition of a handling fee and a flat rate (cents per ton mile) for lake shipment. An additional conceivable movement which was not considered for Western coal shipments to Ohio is by rail to Sioux City, Iowa (head of navigation on the Missouri river) or St. Louis Missouri and then by barge up the Ohio River.

K. Estimated Transport Cost - Least Cost Mode

The two tables below show the cost and mode of coal movements to utility and industrial consumers in Ohio. Generally speaking, rail movements were preferred.

Table V-3

Power Plant Transportation Cost Matrix
(¢/ton)

Plant# \ Region	Pennsylvania	Ohio	Northern West Virginia	Central Appalachia	Midwest	Utah - Colorado	Northern Great Plains
Acme	588	443[a/]	565[a/]	634	-	1290	1000[g/]
Ashtabula	366[a/]	410[a/]	435[a/]	650	-	1400	1000[g/]
Avon Lake	410[a/]	282[a/]	410[a/]	650	-	1385	1000[g/]
Bayshore	588	410[a/]	565	565[a/]	-	1290	1000[g/]
Beckjord	600[f/]	475[f/]	600[f/]	391[f/]	400[f/]	1325	1300
Burger	646	200[d/]	325	451[f/]	550[f/]	1400	1370
Cardinal	383[a/]	170[a/]	165[a/]	466[a/]	575[f/]	1400	1370
Conesville	588	0[c/]	395	618	-	1375	1340
East Lake	403[a/]	282[a/]	410[a/]	650	-	1385	1000[g/]
Edgewater	588	419	563	634[f/]	-	1385	1000[g/]
Gavin	725	475	550	351	450[f/]	1355	1330
Gorge	588	340[e/]	395	634	-	1375	1340
O. W. Hutchings	655	573	648[f/]	548[f/]	-	1325	1300
Kyger Creek	500[f/]	475[a/]	416[f/]	351[f/]	450[f/]	1355	1330
Lake Shore	444[a,b/]	517[a/]	410[a/]	650	-	1385	1000[g/]
Mad River	655	573	648	548[f/]	-	1325	1300
Miami Fort	655	573[c/]	648	401[f/]	350[f/]	1325	1300
Muskingum River	690	0[c/]	450	588	-	1400	1370
Niles	550	461	450	650	-	1400	1370
Norwalk	588	490[a/]	565	634	-	1290	1270
Philo	690	311[a/]	450	588	-	1375	1340
Picway	613	490	566	597	-	1350	1325
Piqua	655	573[d/]	648	548	-	1325	1300
Poston	690	325[d/]	450	588	-	1375	1340
Sammis	646[f/]	200[d/]	325[f/]	471[f/]	600[f/]	1400	1370
Stuart	525[f/]	461[f/]	440[f/]	381[f/]	425[f/]	1355	1330
F. M. Tait	655	573	648	548	-	1325	1300
Tidd	165[a/]	169[a/]	310[a/]	559	-	1400	1370
Toronto	350[f/]	200[d/]	325	475[f/]	575[f/]	1400	1370
Woodcock	659	580	655	652		1270	1250

Note: See footnotes on following page 38.

Table V-3 (cont'd)
Power Plant Transportation Cost Matrix
(¢/ton)

Footnotes:

a/ Weighted average of several applicable rates, single-car, multiple-car, unit train or annual volume rates.

b/ Average of prices from two Bureau of Mines supply regions.

c/ Coal received via conveyor.

d/ Truck.

e/ Average of truck and rail.

f/ Barge, transrail - limited to water-accessible plants.

Table V-4

Industrial Transportation Cost Matrix

Delivery Region	Supply Region 1	2	3	4
01	659	580	655	652
02	588	490	565	634
03	588	419	563	634
04	550	461	450	650
05	588	465	540	618
06	588	320	395	634
07	613	491	566	597
08	690	325[a/]	450	588
09	646	200[a/]	325	559
10	655	573	648	548
11	725	475	550	483

a/ Truck, all else single-car rail.

Note: All prices in ¢/ton.

SECTION VI

DELIVERED PRICE

The delivered price to each consumer is determined by the model FOB mine cost plus the transportation cost. For each powerplant or demand region, a matrix of delivered costs has been developed which shows the delivered cost by sulfur content by supply region. For each powerplant this matrix has 6 sulfur content categories and 7 supply regions for a total of 42 possible delivered cost elements. Industrial demand regions are limited to 4 supply regions and 6 sulfur categories. 1/

For each facility the regulation is read, and the required sulfur content is determined. The coal which will be used is then the lowest cost coal within the required sulfur content category.

An example of one of the powerplant delivered cost matrices is shown in Table VI-1. If this powerplant is required to burn coal in sulfur content category 2, it can be seen that the lowest cost coal in this sulfur category is from the Northern Great Plains at a cost of 93.3¢ per million Btu. These prices provide inputs to the control strategy selection model (see document #6) to determine the choice of the coal to be used in compliance with an applicable regulation.

1/ The two Western coal regions were excluded because costs were not provided in Document #9 on derates and conversion from current coal to Western coal.

Table VI-1

Delivered Cost Matrix Example Powerplant

Sulfur Category (#/MMBtu)

Supply Region	less than .8	.8-1.2	1.3-1.7	1.8-3.3	3.4-5.0	greater than 5.0
1	-	-	122.0	103.1	87.0	81.7
2	-	-	-	94.1	78.2	68.6
3	-	-	-	108.6	92.1	92.1
4	141.6	118.1	117.3	104.3	-	-
5[a/]	-	-	-	-	-	-
6	-	113.6	113.6	-	-	-
7	-	93.3	82.8	-	-	-

a/ Transportation link does not exist to this plant from Indiana-Western Kentucky.

APPENDIX A

METHODOLOGY

A. Approach

A generalized description of the model used to derive the implications of alternative regulatory scenarios is shown in Figure A-1. The basic logic of the solution is as follows:

- project levels of coal demand by sector (e.g., utility, metallurgical uses);
- set sulfur limits on the demands by imposing an environmental regulatory scenario;
- provide options to meet the coal demands by sulfur content which
  - allow coal purchases from various supply regions, and
  - allow application of sulfur removal equipment with high sulfur coal.
- solve the model to minimize total delivered cost of coal to all users; and
- generate outputs related to cost, reliance on sulfur removal equipment and coal production patterns.

Each of the components of the model is discussed briefly below.

B. Coal Demand

The demand for coal was projected for 1980, 1985 and 1990 for six sectors, as shown in Table A-1. For the purposes of

FIGURE A-1

COAL SUPPLY/DEMAND MODEL

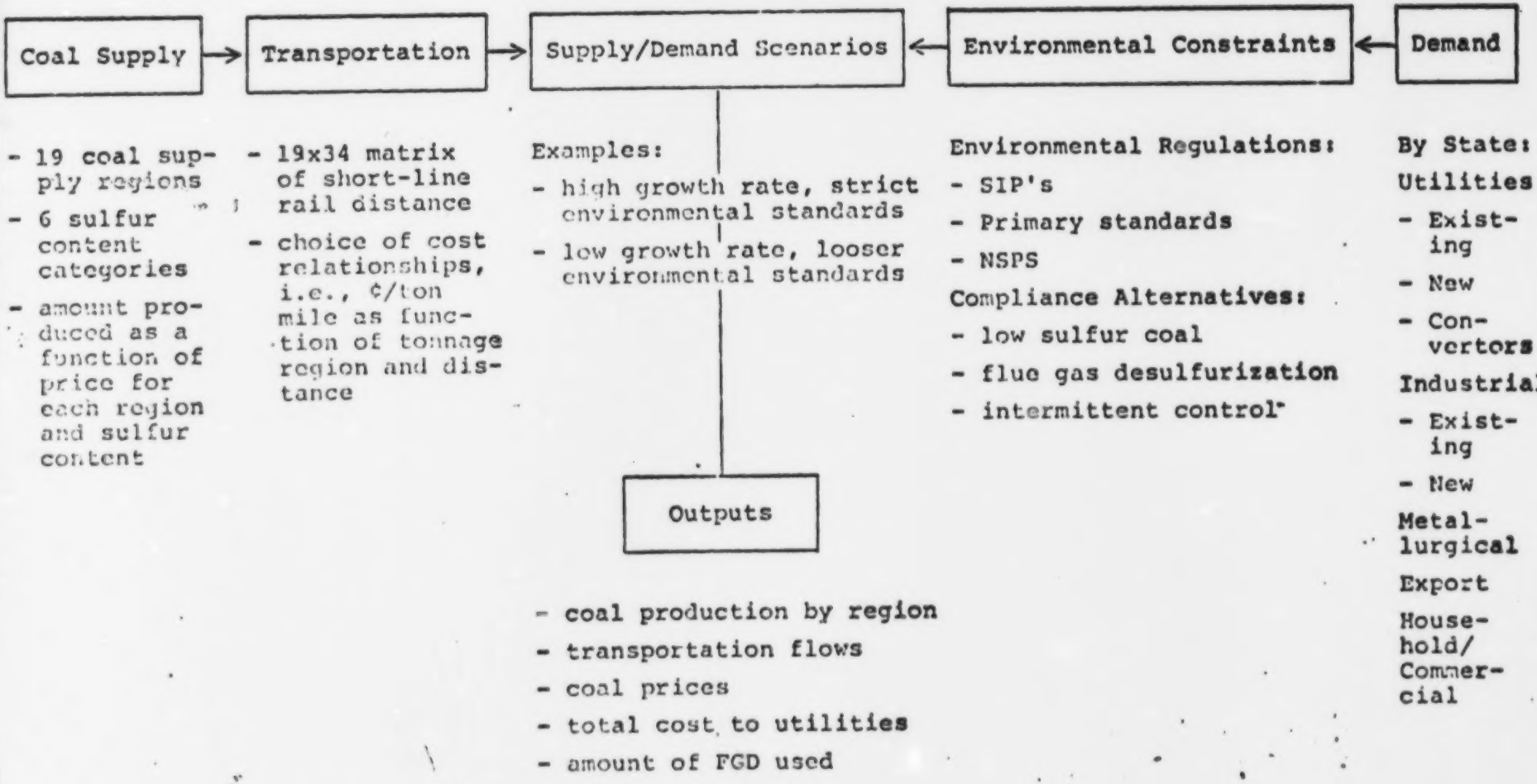


TABLE A-1

TOTAL PROJECTED COAL DEMAND

	1974	1980	1985	1990	% Annual Growth
Coke	91	100	110	120	2
Industrial	66	103	123	204	7
Commercial & Household	8	12	15	15	4
Metallurgical Exports	55	58	67	73	2
Steam Coal Exports	11	25	35	45	9
Utility Demand	392	605	878	1148	7.0
TOTAL DEMAND	623	903	1228	1605	6.1

this study, the highest practicable growth rate in coal demand was utilized to emphasize the maximum possible environmental repercussions. A lower growth rate for coal would reduce the demands for low sulfur coal and control equipment, thereby reducing the costs of compliance with Clean Air Act regulations.

Coal demand for domestic uses was projected by state. Past regional patterns of coal use by sector were assumed to continue in the future, except for electric utility demand, which was allocated by state on the basis of expansion plans filed with the Federal Power Commission.

C. Sulfur Content

One set of requirements for all coal-using sectors, except utilities, was developed according to the following assumptions:

- industrial and residential-commercial coal users were assumed to comply with applicable state sulfur regulations;
- two-thirds of new steam coal use by industry after 1976 was assumed to be subject to Federal New Source Performance Standards; and
- metallurgical coal demand was assumed to maintain its 1972 composition of demand by sulfur content, as was demand for coal for export.

Sulfur requirements for coal-fired steam electric power plants were developed on a plant-by-plant basis keyed to the regulatory scenarios. For each plant, the following sets of possible environmental limits were used:

- latest enforceable state sulfur regulations;
- proposed new regulations related to EPA's Clean Fuels Policy;
- share of total sulfur emissions contributed by the plant within an air quality region; and

- the estimated level of coal sulfur content associated with the achievement of the 24-hour health standard.

Once a maximum sulfur limit (based on the above data) was determined by the regulatory scenario, the model determined the volume of coal in compliance which included all coal which could be blended with lower sulfur coal to bring this coal into compliance with the sulfur limit. In effect, 1974 coal use by plant was separated into "complying" coal and non-complying coal. All coal in new power plants was designated as non-complying.

D. Sulfur Removal Technology

Once the volume of non-complying coal in each plant is estimated, as described above, two options are available to meet the applicable sulfur limit.

Appropriate quality coal can be used to meet the demands. The model selects the source of the coal in order to minimize delivered costs to the thirty-four demand regions.

An option is also developed which allows sulfur control equipment and a higher sulfur coal to be chosen. Costs of control equipment (FGD) are determined according to the following logic:

- FGD costs per boiler with coal-firing capability are calculated based on size of boiler, age, capacity utilization, and whether the boiler is a new or existing unit;
- the least cost set of boilers are selected to determine control costs for non-complying coal in each plant; and

- the non-complying coal is aggregated into six sulfur removal equipment cost categories for each demand region.

The cost minimization model will compare the delivered cost of appropriate quality coal with the combined cost of sulfur removal plus higher sulfur coal, and select the least cost alternatives.

E. Coal Supply Curves

Three characteristics of coal reserve's essential parameters for this study are: mining costs, sulfur content and heat value. The last two, when combined, determine the environmental acceptability of the coal. Supply curves for six sulfur content categories were developed for each of nineteen coal supply regions. Up to twenty cost segments were developed for each supply curve.

Strip mineable and underground reserves were analyzed separately according to the following logic:

- the volume of economically recoverable reserves in each sulfur content category, as defined by the Bureau of Mines at the county or state level, was the basic data-building block;
- these reserves were reduced to account for recovery rates, reserve blocks too small to be mined, reserves which cannot realistically be mined (e.g., below towns), reserves lost due to strip mine legislation;
- the remaining reserves were then characterized by stripping ratio for strippable reserves; by seam thickness and mine size for underground reserves;

- estimates of coal production costs were developed for each type of mine, modifying the Bureau of Mines' data on the basis of conversations with coal mining experts;[1/] and
- the last two steps were combined to generate reserves stratified by costs.

These reserve data were converted into potential coal production by dividing by 20, which assumes a twenty year period of operation for a mine. Although it will almost certainly take longer to develop coal reserves (i.e., reserve production ratios will be above 20), these maximum potential production levels were used in the initial runs of the model.

The sulfur content of the potential production levels was assumed to be distributed identically to the sulfur distribution of the reserve data at the county or state level. Differences in the cost of coal by sulfur content, therefore, can occur as a result of:

- cost of production by sulfur content differs within a state;[2/]
- differences in overall underground and strippable coal supply curves between states with varying sulfur content coal; and
- the volume of coal in each sulfur content supply category in relation to the demand for that quality coal.

F. Transportation Costs

A matrix of transport costs between the nineteen coal supply

1/ Different model mine cost data were used for various regions of the nation.

2/ For example, most thicker seams in Appalachia are medium to high sulfur coal, therefore, low sulfur Appalachian coal will tend to cost more than higher sulfur coal from that region.

regions and the thirty-four demand regions was developed. Costs were estimated for two modes of transport, barge and rail. Rail transport costs were based on estimates of average distance between coal shipment centers and rail receiving centers within each of the demand regions. Costs per ton mile were based on sample data taken from waybills reflecting large coal shipments for utilities.

G. Cost Minimization

The model is solved with a linear programming algorithm which minimizes the total costs of production, transportation and installing/operating sulfur removal equipment. The costs determined in the model reflect long run equilibrium prices; in effect, the model operates as if all contracts are renegotiated every year. This approach is clearly unrealistic and overstates costs since it fails to account for price agreements made under earlier contracts. Consequently, the cost-related results are shown in terms of differences from the base case, to provide accurate comparisons of the added costs of more stringent environmental regulatory options.

APPENDIX B

INFLATION IMPACT STUDY DOCUMENTATION

This appendix identifies the documents prepared to support the Inflation Impact Analysis of the sulfur oxide regulations prepared by the U.S. Environmental Protection Agency (EPA) for the state of Ohio.

Figure 1 identifies the supporting documents. Document #2 provides an overview of the study methodology and illustrates the depth of analysis contained in the study.

Impact Studies

Documents #3 and 4 are economic impact analyses of the utility and industrial sectors in Ohio. These reports address impacts on prices, output, employment and financial viability. Document #5 summarizes the energy impacts of the regulation in terms of the level of energy demand, shifts from coal to oil likely to occur as a result of compliance with the regulations as well as shifts in coal production patterns. In particular, this report focuses on whether coal production in Ohio, which is generally high in sulfur content, will be adversely impacted.

Cost Minimization

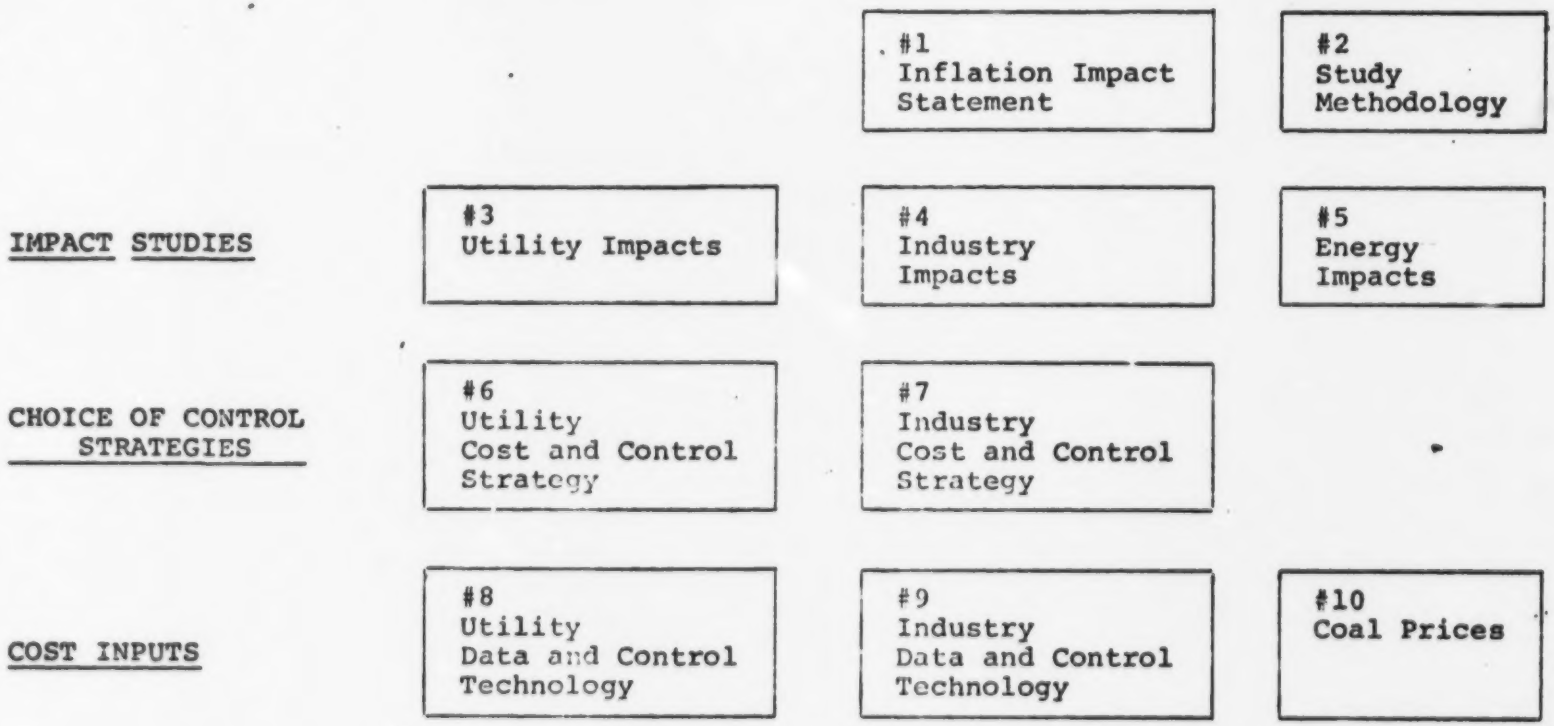
Documents #6 and 7 present the methodology for estimating costs of compliance and the choice of pollution control strategies. For both utility and industry, these supporting documents outline the cost minimizing strategies which provide the basis for the economic and energy impacts discussed in documents #3 - 5.

Cost Inputs

These final documents contain the basic data inputs to the study. Document #8 describes the pollution control technology options, their costs plus basic plant specific parameters which influence costs such as fuel consumption and boiler firing rates.

Figure 1

INFLATION IMPACT STATEMENTS SUPPORTING DOCUMENTS



Document #9 contains similar data on the industrial sector. Document #10 presents the derivation of coal prices employed in this study and used in both the industry and utility sector analysis. The focus is on the price premium of low versus high sulfur coal.